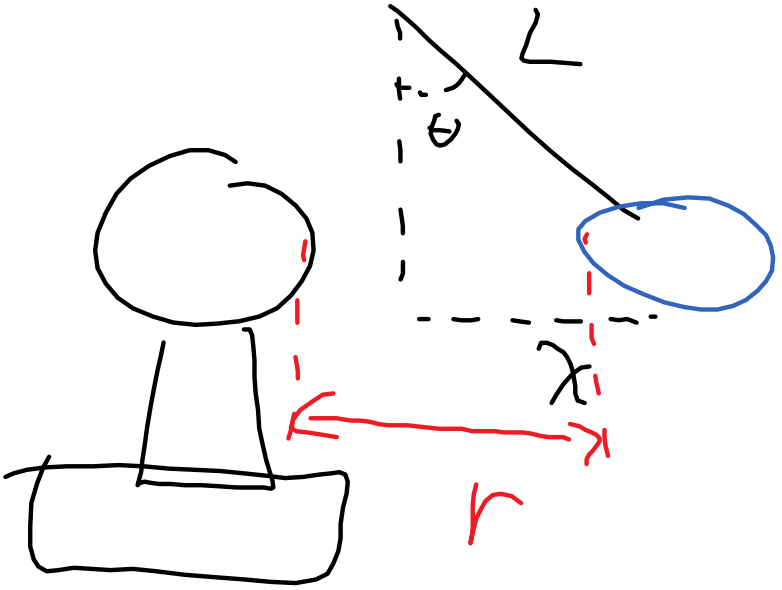
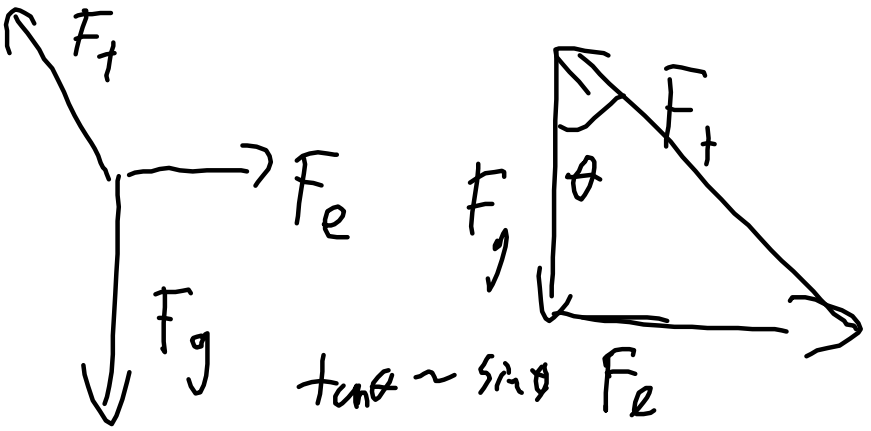
Electric Fields

Van der Graff Generator and balloon
R is the distance between them
X is the deflection of the balloon from vertical

R(cm)	x	
100	22	
80	24	
70	26	
55	35	
48	43	
40	46	

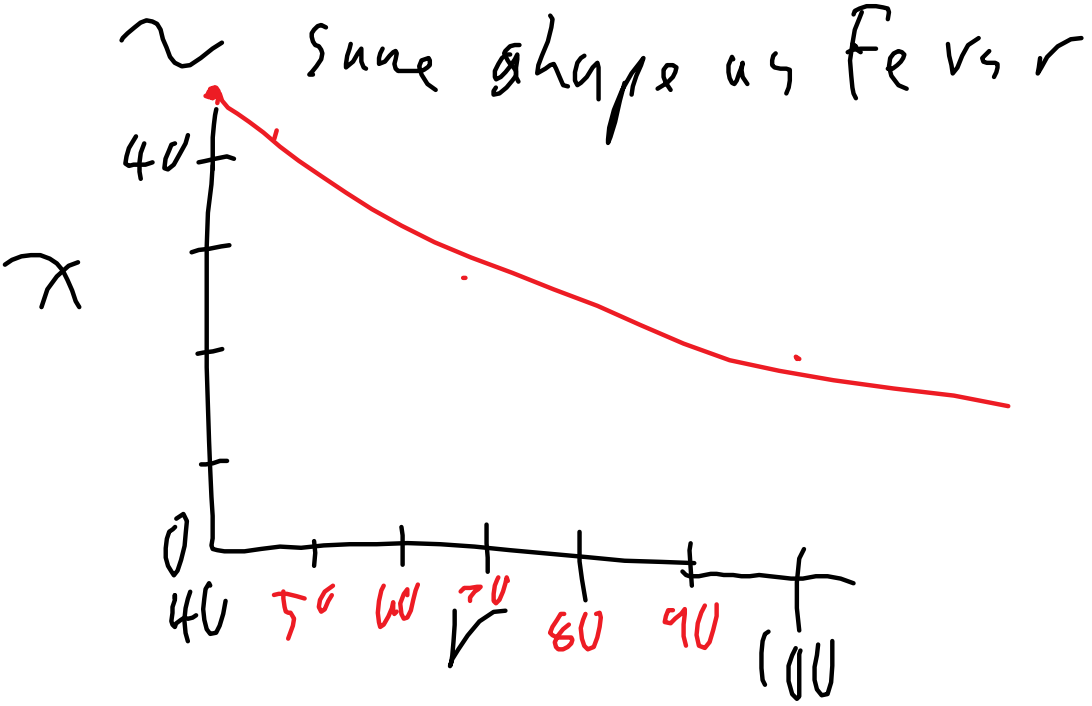




$$\tan\theta = \frac{F_e}{F_g} \approx \frac{x}{L} \quad F_e \propto x$$

So a graph of x vs r

~ same shape as F_e vs r



$$\text{So } F_e = \frac{kQq}{r^2}$$

k is coulomb's constant = 8.99 x $10^9 Nm^2 C^{-2}$
= $1/(4\pi\varepsilon)$
Were ε is the permitivity of free space

Eg what is the force between the electron and proton in a hydrogen atom radius 5.0 x 10^{-11}m? What is the speed of the electron if its mass is 9.11x10^{-31}kg?
F_e=8.99x10^9 x (1.602 x 10^{-19}C)^2/(5.0x 10^{-11}m)^2
= 9.2x10^{-8}N

a= F/m = 9.2x10^{-8}N/9.11x10^{-31}kg = 1x10^{23}m/s^2

$V^2/r=a$ v= root(9.2x10^{-8}N/9.11x10^{-31}kg x 5.0x 10^{-11}) = 2.2 x 10^6 m/s

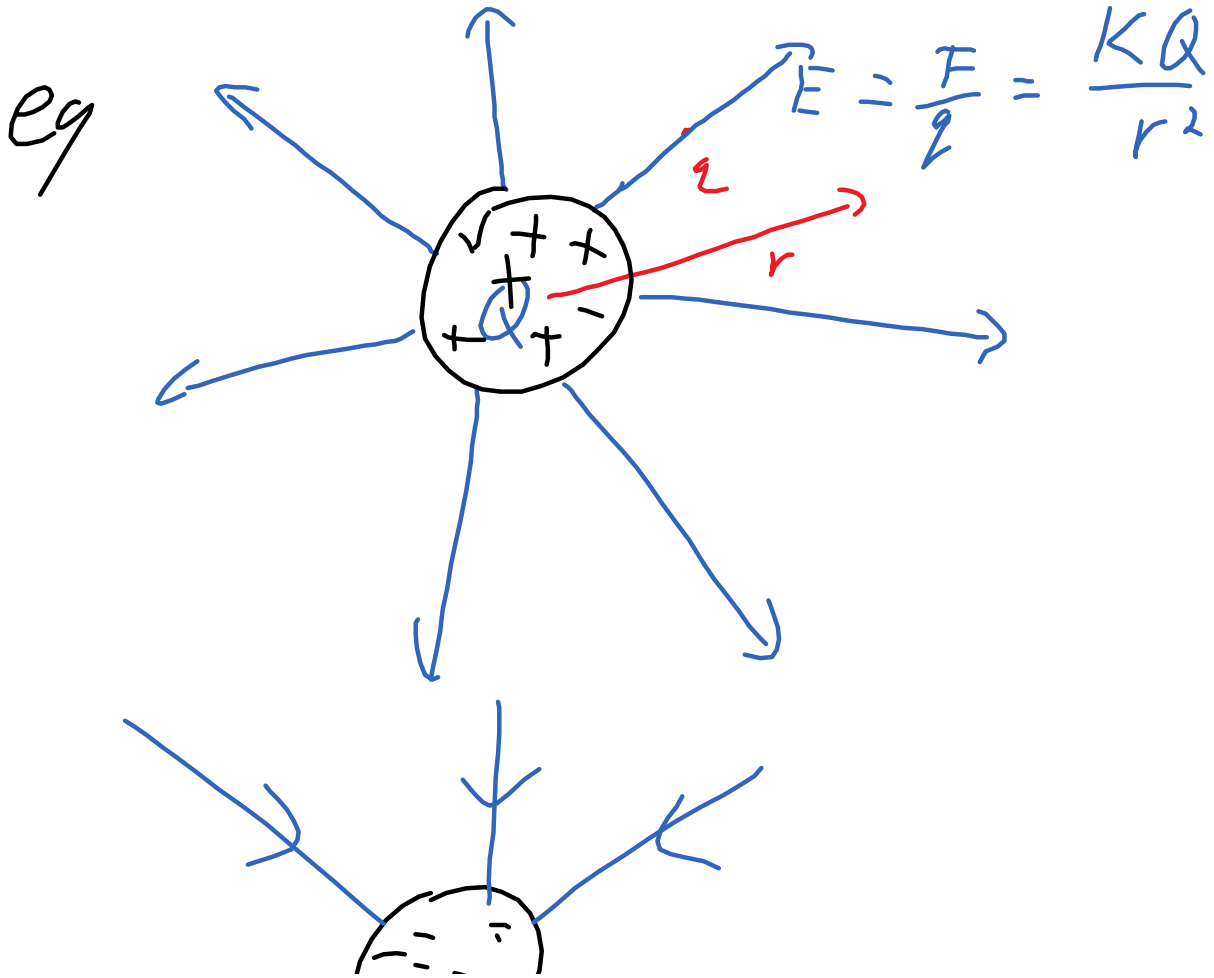
Electric Fields, E.

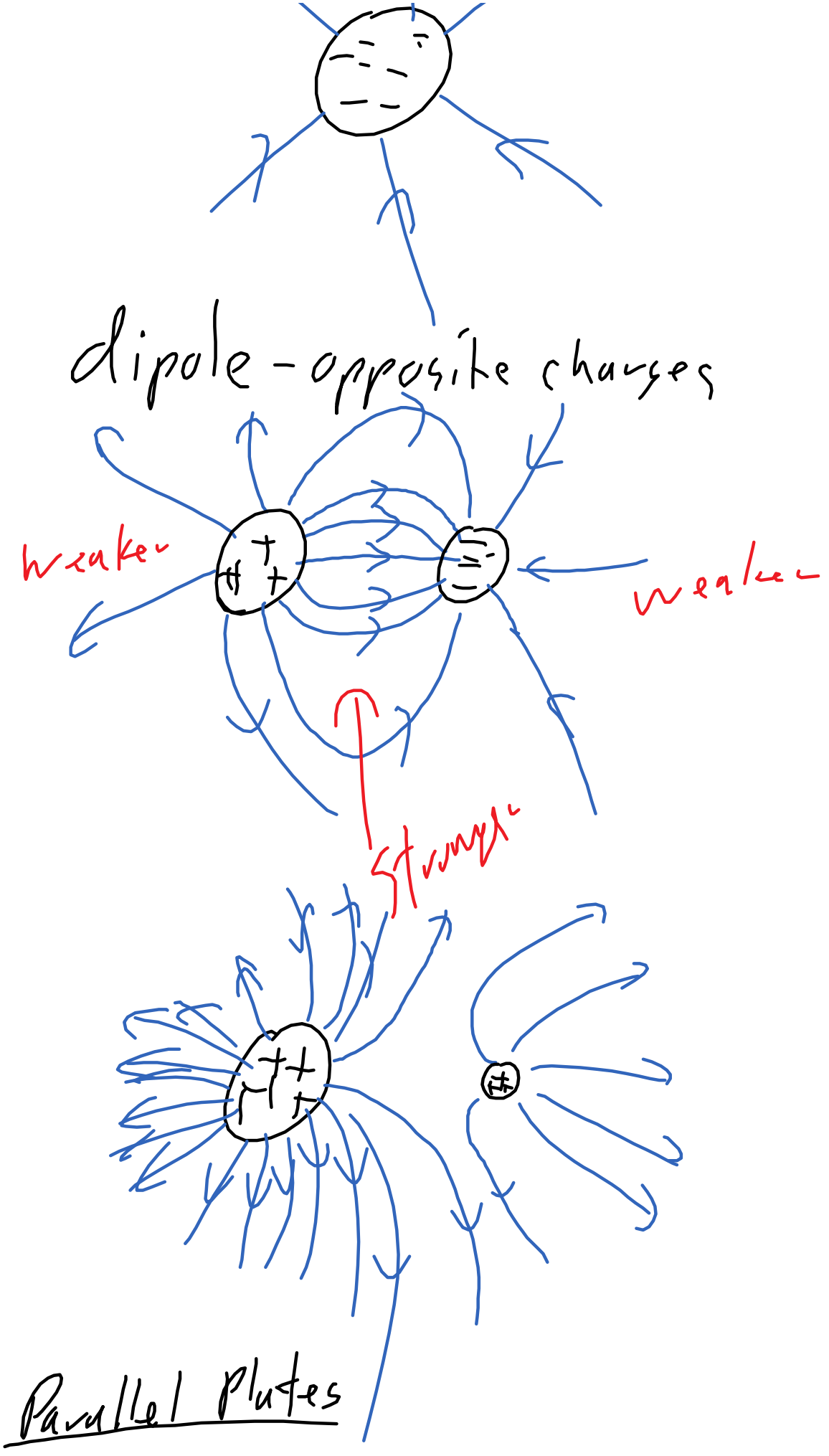
Defined: Force per unit charge on a small point positive test charge, q.
(small amount of charge so it doesn't influence the external charge distribution)

Field Lines: show the direction of force on a point test charge at each location.
If the field line is a curve, the force is tangent to the curve.

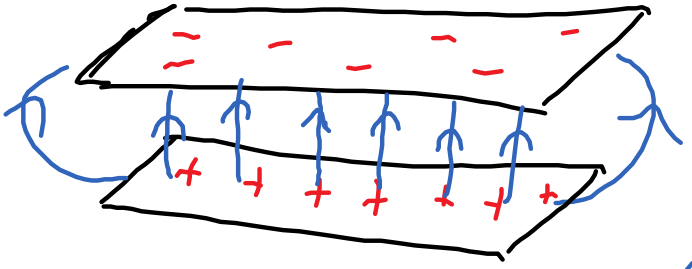
Positive charged metal sphere, negative sphere, dipole, opposite charge, parallel plates

Rules: field lines never cross, always perpendicular to the surface of a conductor.




dipole - opposite charges
weaker
weaker
strongest
Parallel Plates

Parallel plates

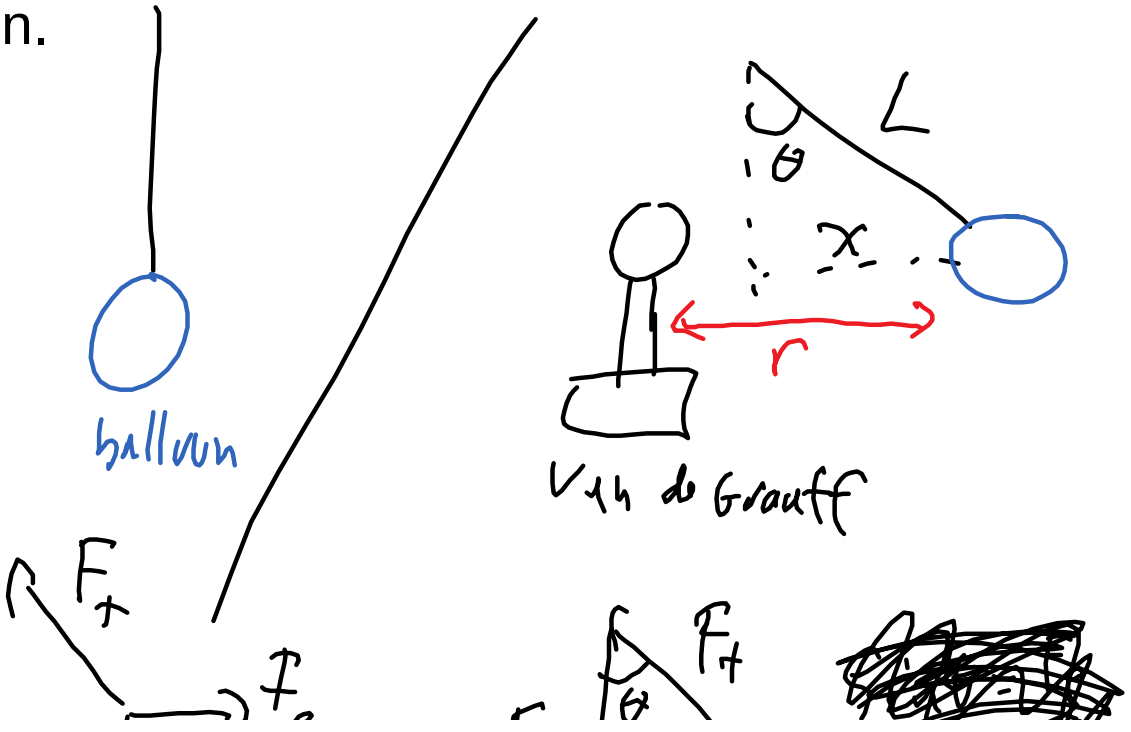


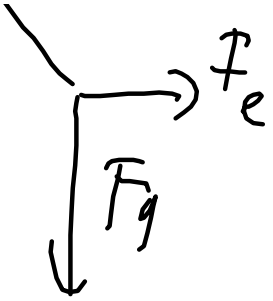
assume E is uniform between the plates, use $E = \frac{F}{q}$ not ~~$\frac{kQ}{r^2}$~~

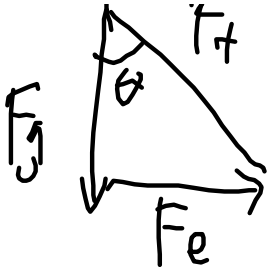
- Capacitors

Electric Fields, E

A Van de Graaff generator builds up charge through rubbing a moving belt.
The balloon will also be charged.
The electrostatic repulsion will deflect the balloon.

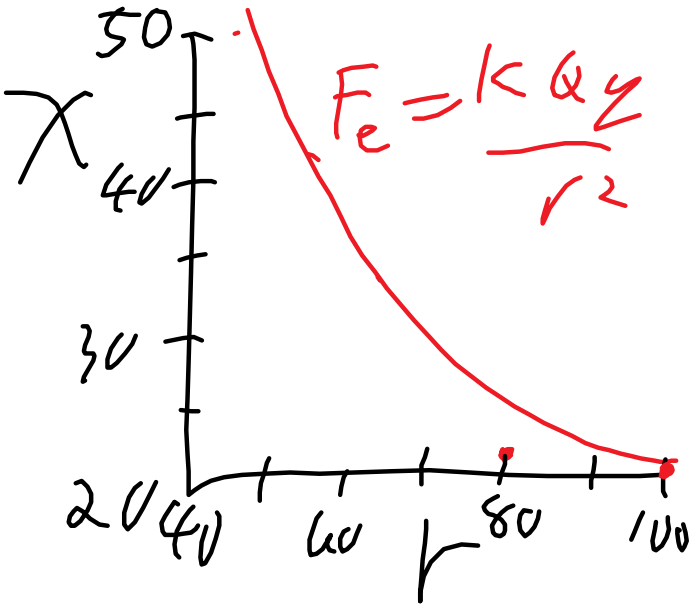






$$\tan\theta = \frac{F_e}{F_g} \sim \sin\theta = \frac{x}{L}$$

x (cm)	r (cm)
20	100
22	80
35	65
41	55
50	45



The force between the balloon and the generator (proportional to x) decreased as distance between their centres, r, increased.

Homework
Eg.
Electron and proton are 5×10^{-11}m apart, determine F and v if circular motion.

$F_e = kQq/r^2 = 8.99 \times 10^9\ Nm^2C^{-2}$

$(1.602x10^{-19}C)^2/(5x10^{-11}m)^2$
$= 9.24 \times 10^{-8}N$

$V^2/r=ac = F/m$
$v= root(Fr/m) = root(9.24x10^{-8}N(5.0 \times 10^{-11}m)/9.11x10^{-31}kg)$
$v= 2.2 \times 10^6$ m/s "orbital" velocity

Drift velocity of electrons is very slow - motion of electrons through a wire

Why do lights turn on so fast?

The electric field moves through the wire at near the speed of light.

Electric Field, E

Define: Force per unit charge on a small, positive point test charge, q.

2 types of problems: 1 caused by a point charge use $E=F/q =kQ/r^2$

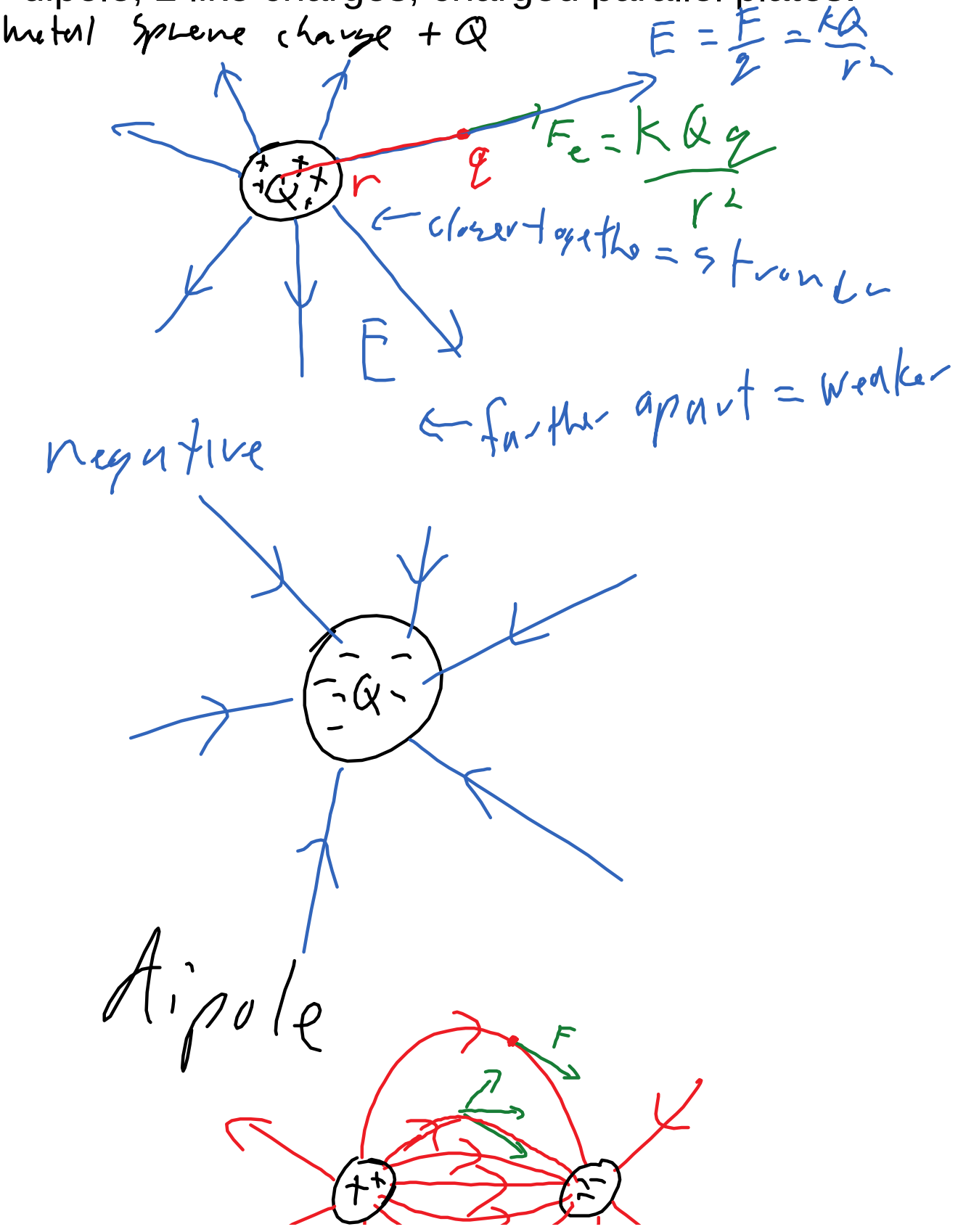
2. Set field - E=F/q or caused by parallel plates E=F/q=V/d(next class)

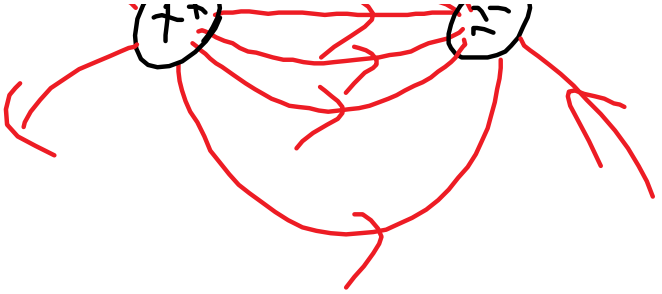
Field Lines:
Lines in space that show the direction of force on a small, positive test charge, q.

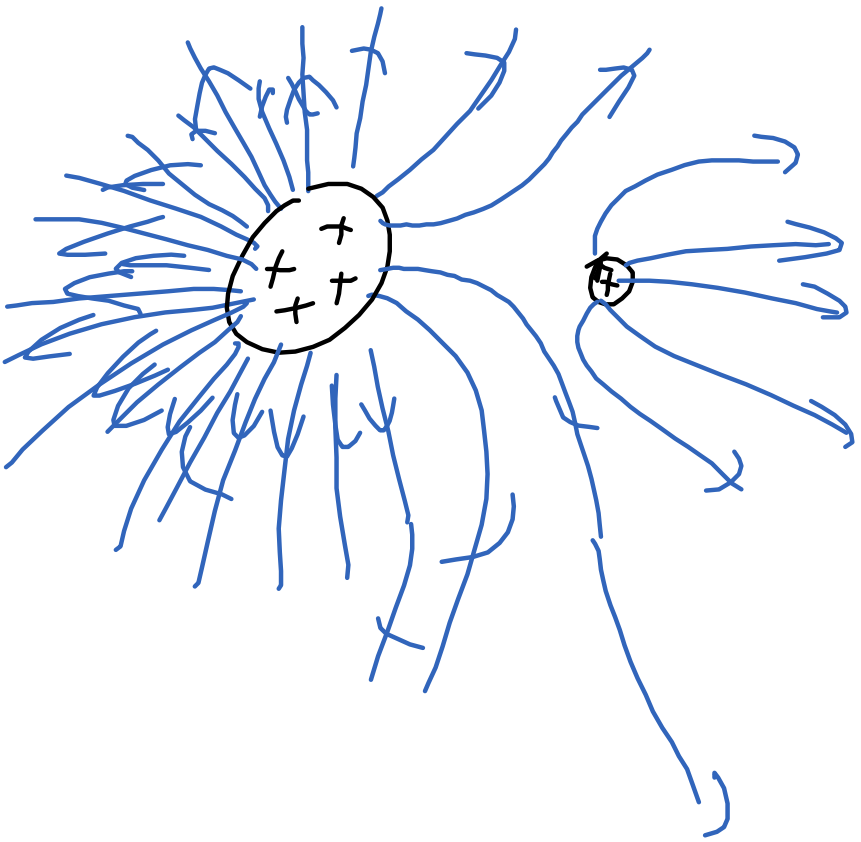
Rules - go away from positive charge
- Go towards negative charge

- Vector sum of all the fields
- Lines never cross
- Always perpendicular to conducting surfaces

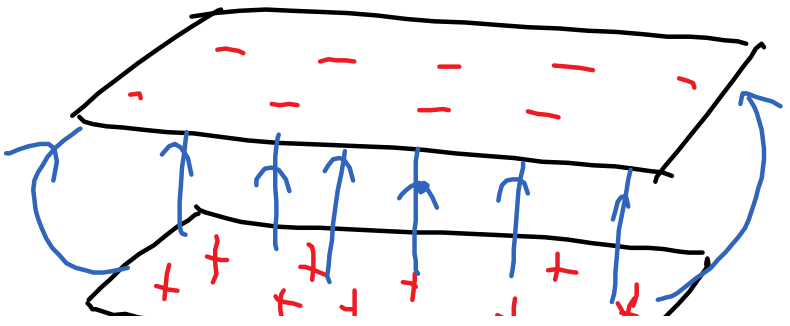
Single positive charge, single negative charge, dipole, 2 like charges, charged parallel plates.

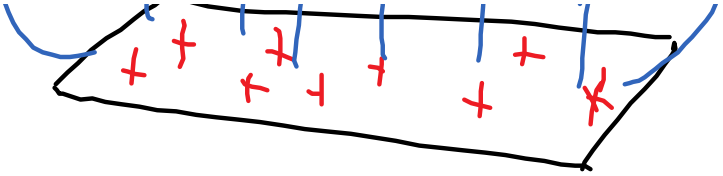






Parallel Plates – Uniform E





effects

Capacitor

http://www.its.caltech.edu/~phys1/java/phys1/EField/EField.html

http://www.falstad.com/vector3de/